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HANDBOOK OF OPERATING AND MAINTENANCE INSTRUCTIONS

FOR

Microline®

MODEL 630
PEAK-POWER METER

SPERRY GYROSCOPE COMPANY
DIVISION OF SPERRY RAND CORPORATION
GREAT NECK, NEW YORK

PUBLICATION NO. 23-1873

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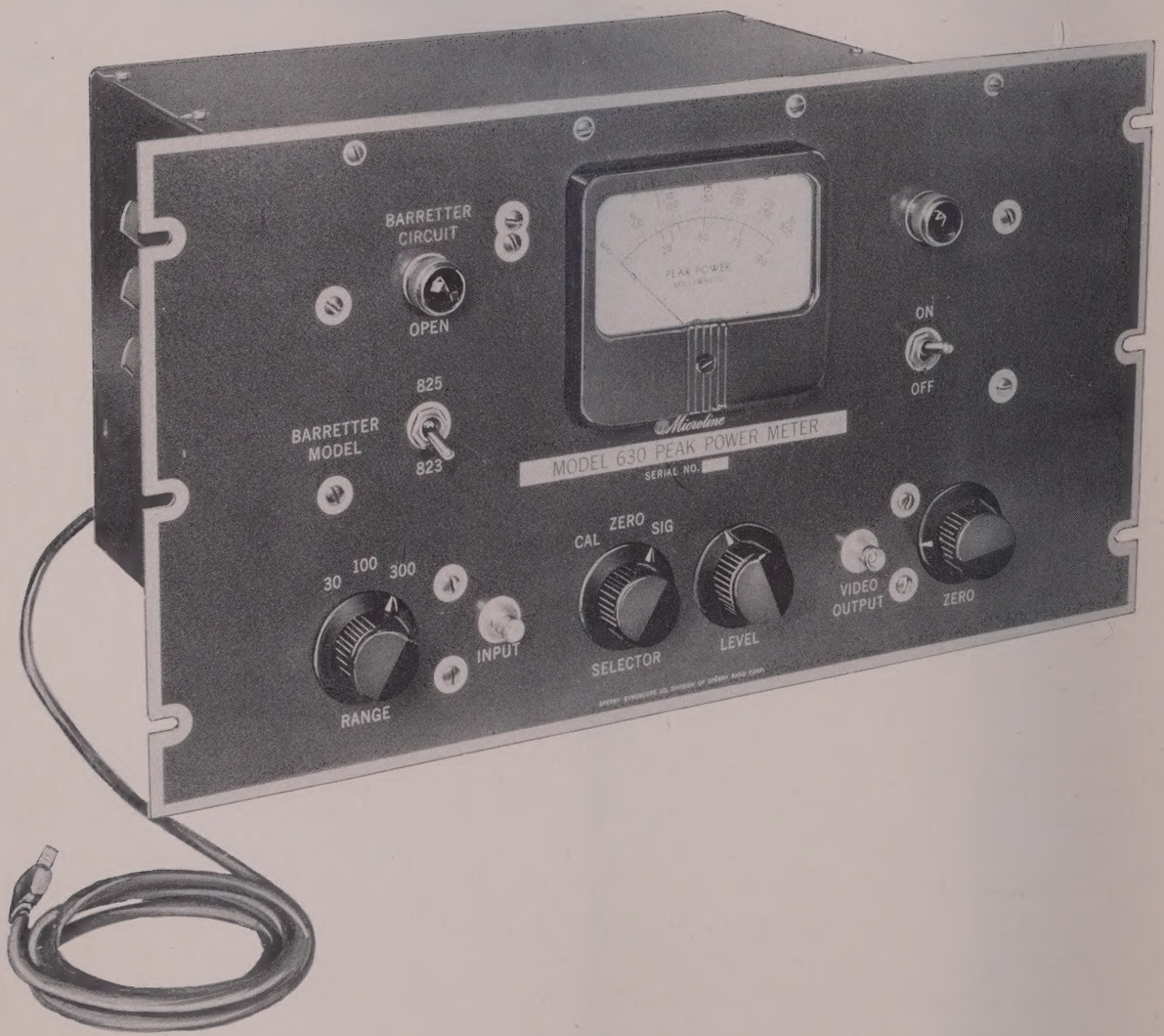


Figure 1. Model 630 Peak-Power Meter - Front View

SECTION A
GENERAL DESCRIPTION

1. PURPOSE OF HANDBOOK

This handbook provides operating instructions, theory, and maintenance information for the Microline® Model 630 Peak-Power Meter.

2. PURPOSE OF EQUIPMENT

The Model 630 provides a convenient and rapid means of measuring the peak power of pulsed microwave signals. Readings are direct and are not dependent upon the duty cycle or repetition rate of the applied signal within the specified ranges of operation.

Typical applications of the peak-power meter are the following:

a. Performance monitoring of radar transmitters

b. Monitoring and check-out of interrogator systems

c. Testing and development of klystrons and traveling-wave tubes.

3. PRINCIPLES OF OPERATION

a. The Model 630 Peak-Power Meter utilizes the sawtooth voltage waveform which is developed across a barretter placed in the electromagnetic field of a pulsed microwave signal.

b. Because of the resistance vs temperature characteristic of the barretter elements used, the slope of the voltage waveform across the barretter is a direct indication of the peak amplitude of the incident pulse. Over the applicable ranges, the slope is not affected by the pulse width or repetition rate.

c. The sawtooth waveform is applied to an active differentiating circuit to produce a pulse waveform within the instrument. The peak amplitude of the pulse reconstructed from the sawtooth is directly related to the slope of the sawtooth voltage.

d. The reconstructed pulse is fed through a diode gate to a detector from which a d-c voltage is derived. The d-c voltage thus developed is proportional to the peak value of the reconstructed pulse and it is used to drive a metering circuit. Through a feedback loop, the diode is biased by the developed d-c voltage so that only a change in the peak amplitude of the applied pulse will be reflected in the developed voltage.

e. For calibration purposes, the instrument contains a circuit which generates a precise sawtooth voltage. This voltage is treated in the same fashion as the input signal from the barretter and it is used to provide a direct calibration each time the instrument is operated.

4. EQUIPMENT SUPPLIED

Table 1 briefly describes the equipment comprising the basic Model 630 Peak-Power Meter. See figure 1.

TABLE I

EQUIPMENT SUPPLIED

Quantity Per Equipment	Name of Unit	Nomenclature	Over-all Dimensions (inches)		
			Length	Depth	Height
1	Peak-Power Meter	Model 630	19	10	8-3/4

5. EQUIPMENT REQUIRED BUT NOT SUPPLIED

a. Operation of the Model 630 Peak-Power Meter requires the use of either a Model 823 or a Model 825 barretter in conjunction with an appropriate barretter mount. These items are not supplied. The barretter mount output capacitance must be less than 100 uuf. The following Microline Barretter Mounts are suitable for use with this instrument:

Barretter Mount Model	Frequency Range (kmc)	Barretter Model
571	2.6-3.95	823
572	3.95-5.85	825
603	5.3-8.2	825
573	8.2-12.4	825

b. In addition, when measuring a microwave signal which is in excess of 300 milliwatts peak power, suitable calibrated attenuators and/or directional couplers must be placed between the microwave source and the barretter mount.

6. PHYSICAL DESCRIPTION

a. The Model 630 Peak-Power Meter is a single-unit, compact, completely enclosed instrument designed for installation in a standard relay rack mounting. All operating controls and indicators are mounted on the front panel of the instrument. It is 19 inches wide, 10 inches deep and 8-3/4 inches high.

b. The inside of the peak-power meter is divided into four functional circuit groups. See figure 2. One group comprises power supply components, which include the power transformer and six electron tubes. A second section contains the calibrate circuit printed board with two tubes, this section developing the calibration signal for the instrument. A third section consists of the video circuit printed board, which contains

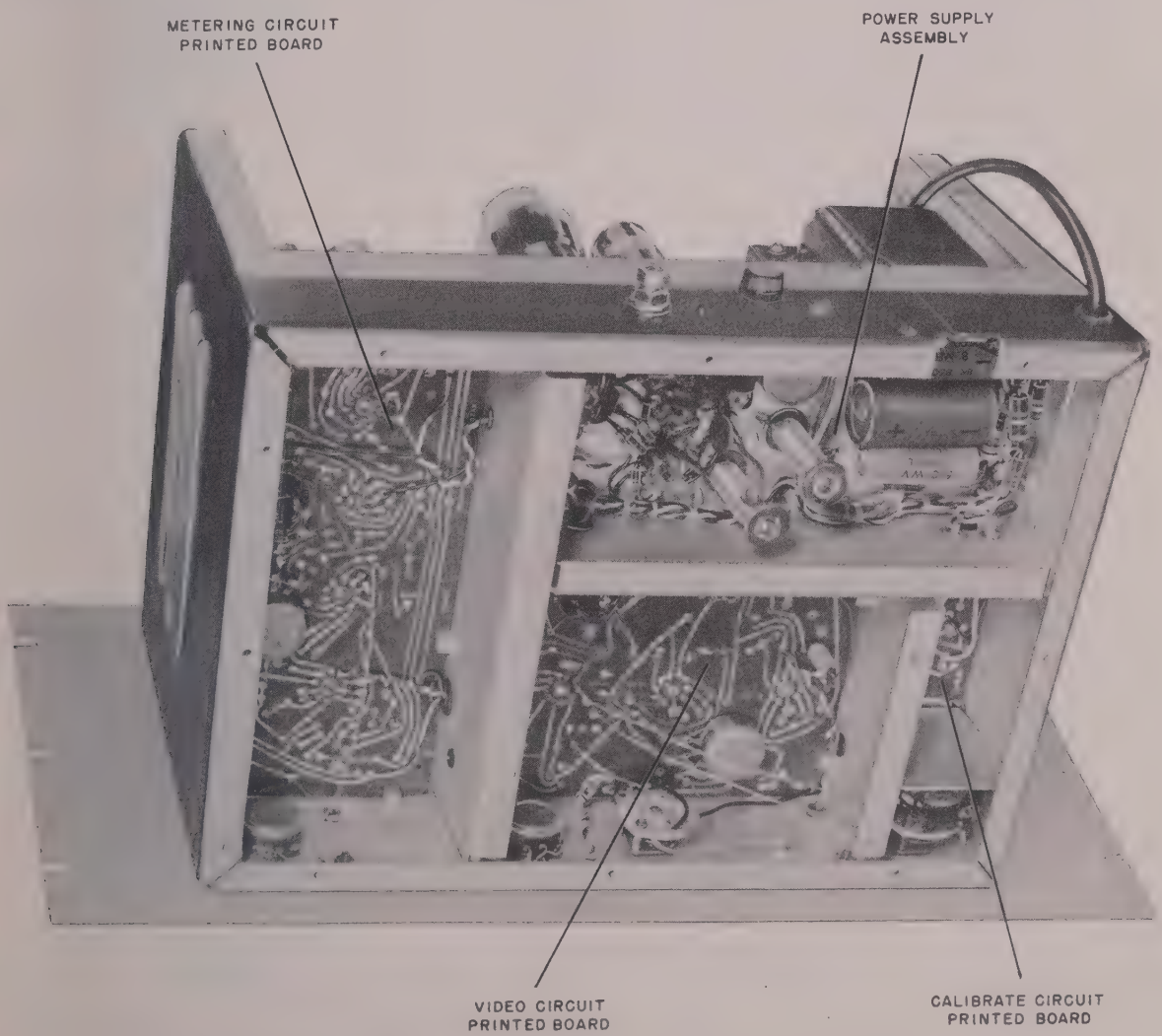


Figure 2. Model 630 Peak-Power Meter - Bottom View, Cover Removed

three tubes for pulse forming and amplifying functions. The remaining section comprises the metering circuit printed board with five tubes which are used to develop the d-c meter voltage.

7. GENERAL CHARACTERISTICS

a. Frequency Range: Depends on barretter mount used

b. Barretter Mount: Any appropriate mount with less than 100 uuf output capacitance

c. Barretter: Sperry Model 823 or 825

d. Power Ranges: 0-30, 0-100, 0-300 milliwatts peak power

e. Accuracy: ±10%

f. Pulse Width: 0.25 to 10 microseconds

g. Repetition Rate: 50 to 5000 pps

h. Rise Time: 0.15 microsecond

i. Video Output (Reconstructed Pulse): 300 millivolts

j. Size: 19 in. long x 8-3/4 in. high x 10 in. deep

k. Weight: Approx. 20 lbs.

l. Mounting: Standard relay rack type

m. Case: Integral shield and dust cover.

SECTION B
OPERATION AND ADJUSTMENT

CAUTION

Before attempting to use the Model 630 Peak-Power Meter, be sure that the microwave power applied to the barretter mount is low enough to prevent damage to the barretter element. Insert appropriate attenuators or directional couplers preceding the barretter mount to keep the incident power on the barretter down to a safe value.

8. PRELIMINARY ADJUSTMENTS

The following procedure prepares the Model 630 Peak-Power Meter for use:

a. Connect the power cable to a source of single-phase a-c power, 115 volts, 60 cps. The power cable is integral with the instrument. Place the ON-OFF switch in the ON position, and check that the power-on lamp directly above the switch is lit. Allow at least five minutes for warmup.

b. Turn the SELECTOR switch to ZERO and then adjust the ZERO control to align the meter pointer with the zero-milliwatt line at the extreme left of the scale.

c. Determine what type of barretter element is used in the barretter mount and then place the BARRETTER MODEL switch on 823 or 825, whichever is applicable.

d. Place the RANGE switch on 300 and turn the LEVEL control fully counterclockwise. Then set the SELECTOR switch on CAL. Adjust the LEVEL control to obtain a full-scale reading on the meter. Finally, turn the SELECTOR switch to SIG.

9. DESCRIPTION OF OPERATING CONTROLS

Table 2 describes the functions of the operating controls of the Model 630 Peak-Power Meter. These controls appear on the front panel of the instrument. See figure 1.

TABLE 2

OPERATING CONTROLS

Name	Function
ON-OFF switch	Applies or removes a-c power in the instrument.
ZERO control	Adjusts the meter pointer to zero before measurements are made.
LEVEL control	Provides calibration of the power-level indicating meter using an internally generated signal.
SELECTOR switch	ZERO: Connects internal circuits for zero-setting power-level indicating meter.
	CAL: Connects internallly generated signal to indicating meter for calibration.
	SIG: Connects external signal to metering circuit for measurement.
RANGE switch	Switches internal attenuator to desired range for measurement of input signals.
BARRETTER MODEL switch	Connects internal calibration circuit for operation with applicable barretter element.

10. MEASURING PEAK POWER

a. To measure peak power, perform the preliminary adjustments and then connect the barretter mount output to the INPUT jack on the front panel of the peak-power meter. If the BARRETTER CIRCUIT lamp is lit, the barretter element in the barretter mount is open or missing. Install a new barretter before proceeding.

b. The most accurate readings are obtained on the upper half of the meter scale; hence, turn the RANGE switch to the lowest setting for which the meter pointer remains on scale.

c. Because of the high gain in the video amplifier, when operating on the 0-30-mw scale, a meter reading of about 5 mw will be evident with zero signal input. This is normal and does not seriously affect the accuracy above 15 mw.

d. The peak power indicated by the meter is that incident on the barretter element. If a directional coupler or an attenuator is used between the source and the barretter mount, the peak power of the source can be calculated from the following relationship:

$$P_s \text{ (mw)} = P_m \times 10^{(0.1a)}$$

where

P_s = peak power of source (mw)

P_m = peak-power meter reading (mw)

a = db value of directional coupler or attenuator.

11. SECONDARY USES OF THE PEAK-POWER METER

a. The peak-power meter can be used for the monitoring of a microwave signal incident on the barretter.

b. For simple monitoring where it is desired only to check for the presence of the microwave signal, no auxiliary equipment is required. With the peak-power meter connected to the barretter mount, the deflection on the panel meter serves to indicate the presence of the signal.

c. If it is desired to check the pulse shape and pulse spacing of the microwave signal, connect the VIDEO OUT jack to an external oscilloscope. This also makes it possible to compare relative pulse amplitudes where a series of pulses occurs each repetition interval.

d. The reconstructed video pulse signal which is available at the VIDEO OUTPUT jack can also be used as a synchronizing signal for external equipment, such as a synchroscope.

SECTION C
THEORY OF OPERATION

12. BLOCK DIAGRAM DESCRIPTION

a. The block diagram for the Model 630 Peak-Power Meter is shown in figure 3. Main signal flow is indicated by heavy lines on the diagram.

b. For the CAL position of SELECTOR switch S502A, a sawtooth signal is fed to the input stage of tube V301. The sawtooth voltage is generated in the calibrate circuit and it is used to calibrate the peak-power measuring circuits. Tube V402 comprises a circuit for generating and forming a precise square wave which is integrated to form a sawtooth voltage similar to that received from the barretter.

c. For the SIG position of the SELECTOR switch, the input signal to be measured is obtained from the barretter. When a pulsed r-f signal is applied to the barretter, it does not heat up instantaneously; rather, the temperature curve is essentially linear with time for periods of 10 microseconds or less. Since the resistance of the barretter is proportional to its temperature and it is biased from a constant-current source, a sawtooth voltage is developed across the barretter. The slope of the sawtooth is the important characteristic since it is directly related to the peak amplitude of the applied pulse.

d. The sawtooth voltage from the barretter is differentiated in V301 and the resulting pulse waveform is applied through V302 to a high-frequency compensated divider. Following amplification in V303 and V205B, the pulse signal is applied to neutralizing amplifier V205A.

e. The main signal from amplifier V205A is coupled through coupling diode V204A to amplifier V203. The signal is further amplified in V202 and then detected in V201A to obtain a d-c voltage proportional to the peak value of the pulse signal. A feedback loop is employed to control conduction in coupling diode V204A so that conduction is a function only of the peak amplitude of the applied pulse, not of the repetition rate or pulse width.

f. A neutralizing voltage is fed from amplifier V205A to amplifier V203 to offset the capacitive coupling effect of the diode.

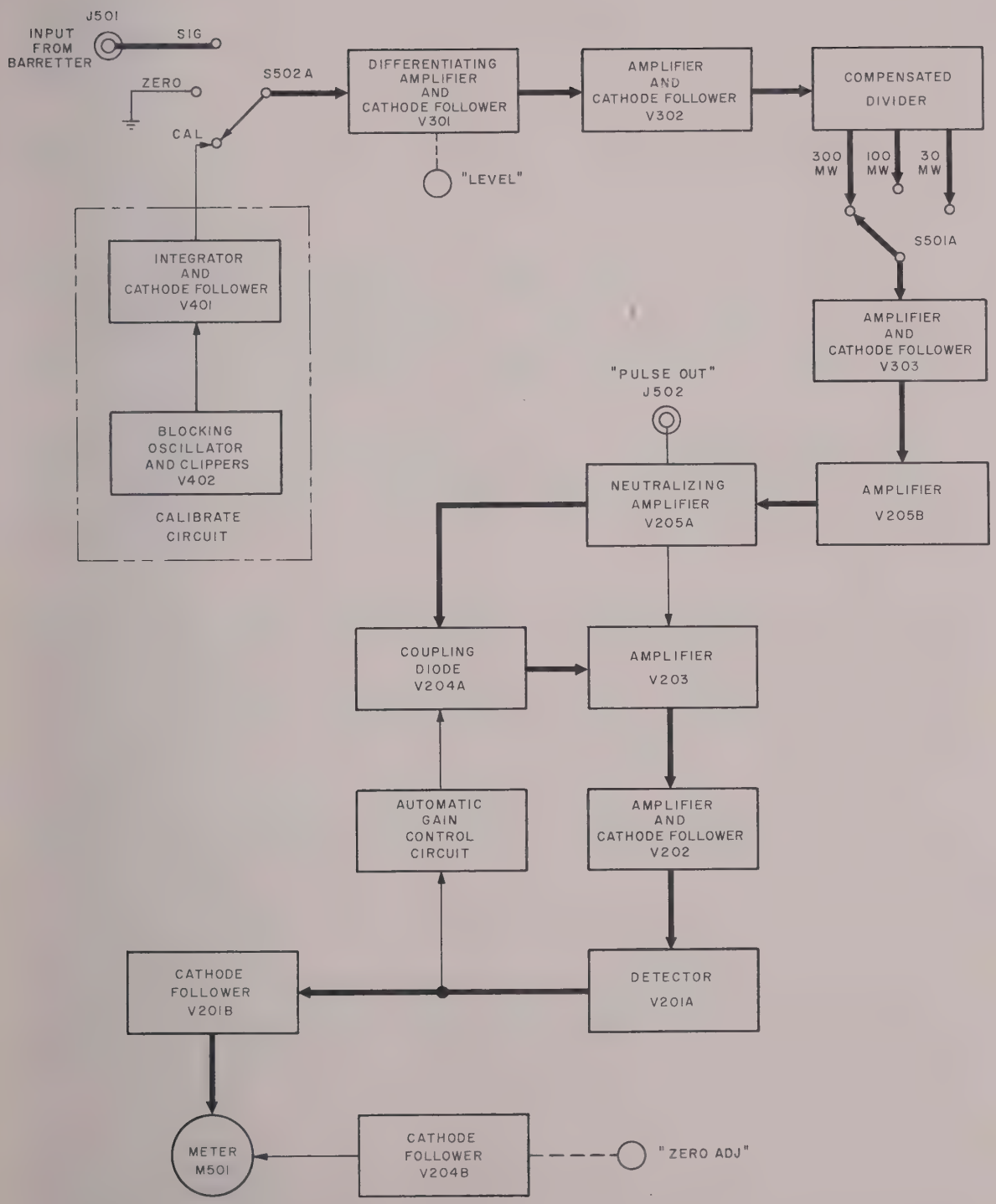


Figure 3. Model 630 Peak-Power Meter, Block Diagram

g. The d-c voltage developed at the output of detector V201A is applied to cathode follower V201B. The meter indication is proportional to this developed voltage. In the absence of an input signal, cathode followers V204B and V201B are balanced so that no current flows through the meter.

13. CIRCUIT ANALYSIS

a. The schematic diagram of the Model 630 Peak-Power Meter is shown in figure 6.

b. The triode section of tube V402 is used in a conventional, free-running blocking oscillator circuit. A positive output pulse is developed across resistor R405 and the negative overshoot is clipped by the diode in parallel with the resistor. CAL ADJ potentiometer R510 sets a positive voltage level at the cathode of the second diode section. Hence, the positive pulse amplitude is clamped to the voltage set by R510.

c. The positive pulse from the blocking oscillator is coupled to an integrating circuit consisting of R410, C406 and C407. The resulting sawtooth voltage is applied to cathode follower V401. The cathode load of this stage is tapped at three points so that the calibrating voltage selected by RANGE switch S501 corresponds to the applicable range for the signal to be measured.

d. The input circuit of V301 is connected to SELECTOR switch S502. For the CAL position, the sawtooth signal is selected from the Calibrate Circuit, and LEVEL potentiometer R502 adjusts the gain of the pentode section of tube V301 so that the chosen calibrating signal produces full scale deflection on meter M501. For the ZERO position, the input circuit is grounded to permit zero-setting meter M501. For the SIG position, a sawtooth signal is obtained from the barretter element.

e. The barretter is placed in an adjustable resistive divider circuit from B+ to ground to obtain the required d-c bias current. Neon lamp I501 is placed in the circuit for a twofold purpose. First, it acts as a protective device to limit the current if a voltage surge occurs and to keep the open-circuit voltage low if the barretter circuit is open. Secondly, it gives a visual indication if the barretter is burned out or missing.

f. The pentode section of V301 contains an inductor, L301, in the plate circuit, which causes differentiation of the sawtooth signal to produce a pulse signal. The pulse is applied through the cathode follower section of V301 to amplifier V302A. The grid of the amplifier is shorted to ground for the ZERO position of the SELECTOR switch to eliminate noise signals while zeroing the meter.

g. The output of cathode follower V302B feeds through RANGE switch S501 to the applicable section of a compensated voltage divider. For the low range (30 MW), the full signal is applied to the succeeding amplifier stage. For the two higher ranges, however, only a

portion of the signal is used, the divider ratios being chosen to yield full-scale meter readings for applied microwave signals of 100 milliwatts and 300 milliwatts peak power, respectively. Both dividers are high-frequency compensated.

h. The pulse signal is amplified in V303 and then fed through pentode amplifier V205B to neutralizing stage V205A. The main signal, a positive pulse, is coupled from the cathode of V205A to V204A, which is diode connected. The diode couples the signal to amplifier V203.

i. Following V203 are cathode follower V202A, amplifier V202B and infinite impedance detector V201A. Because of detector action, a positive d-c voltage is developed across capacitor C214, the voltage depending upon the amplitude of the signal coupled by the diode. Since the cathode of the diode is d-c coupled to C214 by resistor R213, the signal fed to amplifier V203 becomes smaller and smaller as the voltage builds up on C214. An equilibrium point is reached at which the applied pulse signal is blocked at the diode because of the built-up cathode voltage. At this point, the diode conducts slightly to replace the charge leaking off C214 between pulses. As long as the peak amplitude of the applied pulses remains fixed, the voltage across C214 remains constant; if the peak amplitude of the pulses changes, the voltage across C214 changes correspondingly, with the diode acting as an automatic gate.

j. Because of the interelectrode capacitance of the diode, a small a-c signal is always present across the diode. To counteract this effect, an inverted signal is obtained from the plate of neutralizing stage V205A and coupled by capacitor C211 to amplifier V203.

k. The indicating meter, M501, is connected between the output circuits of two d-c cathode followers, V201B and V204B. In the absence of a signal, the voltage at the cathode of V204B is made equal to that at the cathode of V201B by adjustment of control R501. When a pulsed signal appears, capacitor C214 charges, and the resultant d-c voltage is applied to the grid of V201B. Hence, the meter reading is directly proportional to the d-c voltage developed across capacitor C214.

l. D-c supply voltages for the electronic circuits are obtained from two separate power supply circuits. One is a conventional electronically regulated circuit which supplies +265 volts. The other consists of a half-wave rectifier feeding into an R-C filter and supplying -150 volts. Tube V103 provides a voltage reference to the +265-volt circuit and it also functions as a simple voltage regulator for the -150-volt circuit.

SECTION D
MAINTENANCE

14. GENERAL

a. To gain access to the interior of the Model 630 Peak-Power Meter, remove the single-piece top and back cover. If necessary, also remove the bottom plate. Figures 2 and 4 show the physical locations of the various circuits, components and tubes to expedite troubleshooting and maintenance.

b. As a general rule in troubleshooting, first check the tubes that may be associated with a given symptom, as indicated in the troubleshooting chart. Secondly, be sure that the proper supply voltages are present. Thirdly, make use of the typical waveform information presented in figure 5 to check the various circuits. Finally, use the voltage chart to isolate defective detail parts. Figure 7 lists the detail electrical parts used in the instrument.

c. Be sure that any shields and covers which have been removed make good, firm electrical contact when they are replaced. This is particularly important for the shield around the calibrate circuit. Replace the shield with clean, firm ground connections to prevent radiations and pickup of the blocking oscillator pulses.

15. TROUBLESHOOTING CHART

Table 3 presents some of the possible symptoms of trouble in the Model 630 Peak-Power Meter together with probable causes and remedies.

TABLE 3

TROUBLESHOOTING CHART

Symptom	Probable Cause	Remedy
1. A-c power applied, switch on but power-on lamp not lit.	a. Fuse F501 open or missing.	a. Replace 3-ampere fuse at rear of instrument. If fuse burns out check for internal short circuit.

TABLE 3 (Cont)

TROUBLESHOOTING CHART

Symptom	Probable Cause	Remedy
2. SELECTOR switch on ZERO, meter pointer off scale to left, ZERO ADJ control ineffective.	a. V201 defective.	a. Check V201 and associated circuit of V201B.
3. SELECTOR switch on ZERO, meter pointer deflected to right, ZERO ADJ control ineffective.	a. V204 defective.	a. Check V204 and associated circuit of V204B.
4. Operation normal for ZERO and SIG positions but no meter deflection for CAL position.	a. Calibrate circuit inoperative.	a. Check V401 and V402 and associated circuits. Check waveforms.
5. With r-f signal applied, no deflection on meter for SIG position, nor for CAL position.	a. Tubes V301, V302, V303, V202, V203, V204 and/or V205 defective.	a. Check the indicated tubes; if necessary, place Function Switch on CAL and check waveforms.

16. ADJUSTMENT OF NON-OPERATIONAL CONTROLS

a. General. The following paragraphs describe the manner in which each of the internal controls or adjustments is made.

b. BARRETTER CUR ADJ Control R325 (figure 4). To adjust this control, a 200-ohm resistor and a milliammeter are required. The milliammeter should preferably have a full-scale range of 0- to -10 ma. Connect the resistor and the milliammeter in series between the center conductor and the shield of INPUT jack J501. Adjust R325 to obtain a current of 8.75 ma.

c. +265 ADJ Control R120 (figure 4). For this adjustment, connect a vacuum-tube voltmeter between V104, pin 3 or 6, and ground. Adjust R120 to set the voltage at 265 volts.

d. CAL ADJ Control R510 (figure 4). For this adjustment, connect a vacuum-tube voltmeter (1 percent accuracy on dc) to the center arm of R510. Turn the BARRETTER switch to 823. Adjust R510 to obtain 30 volts dc.

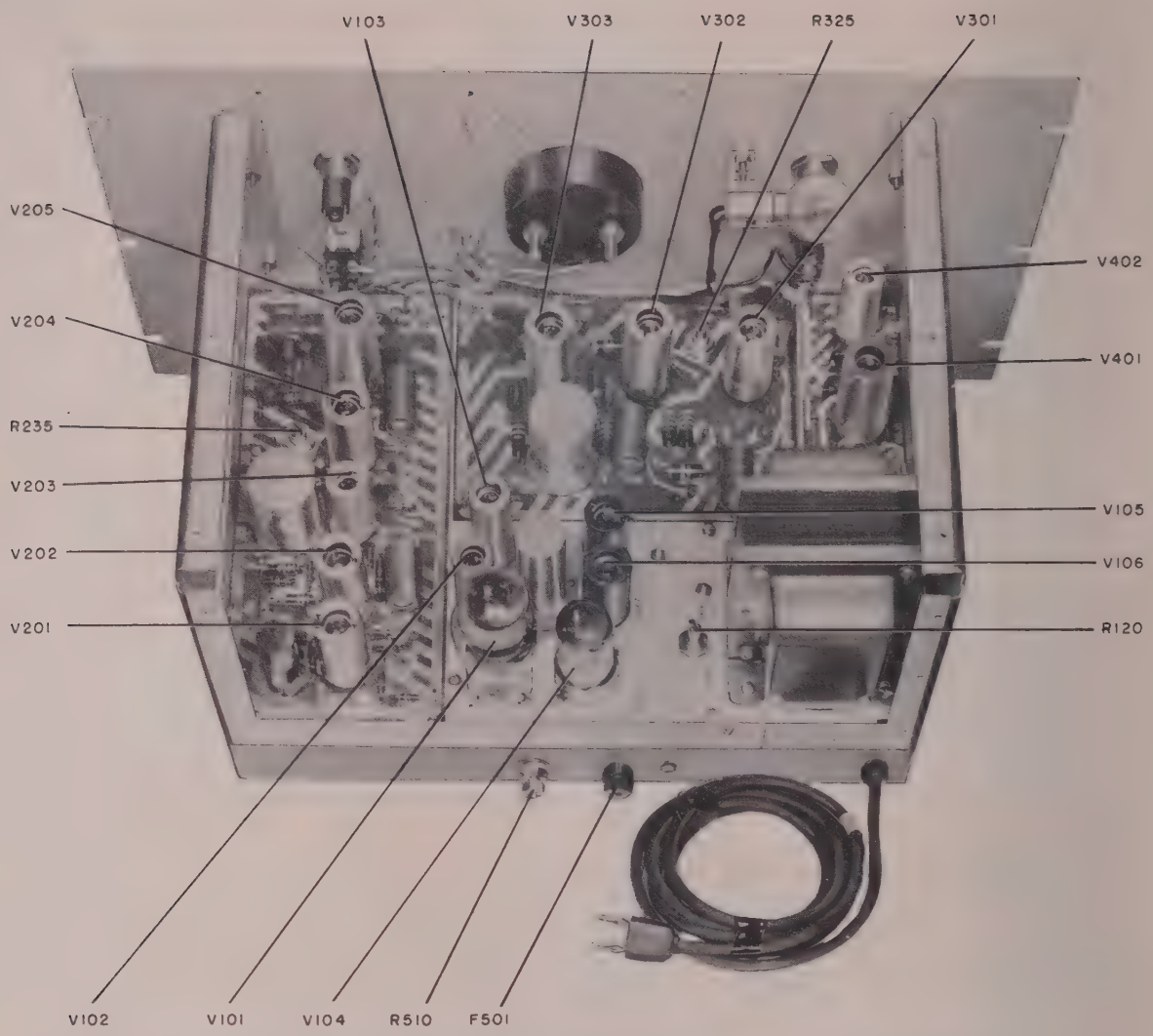
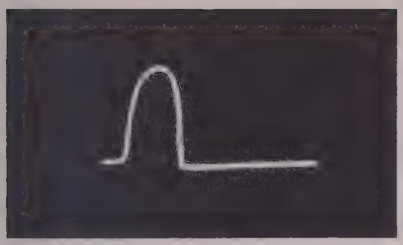


Figure 4. Model 630 Peak-Power Meter - Top View, Cover Removed

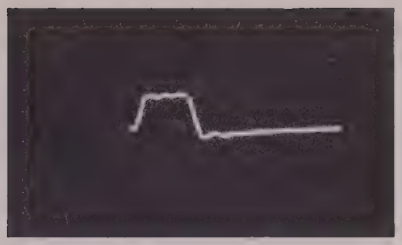
NOTE

Since the adjustment of R510 depends upon the supply voltage, be sure that R120 is adjusted, if necessary, before R510 is set.

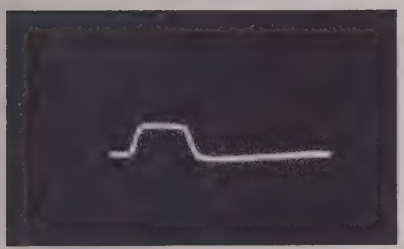
e. NEUT Control R235 (figure 4). Before adjusting this control, turn the SELECTOR switch to ZERO and adjust the ZERO ADJ control on the front panel to zero the panel meter. Then apply a positive pulse signal from a pulse generator to V205, pin 2, the pulse being 10 microseconds wide and having a repetition rate of 5000 pps. Adjust the pulse amplitude at the pulse generator to obtain full-scale deflection on the panel meter. Minimize the meter reading by adjusting R235. Again adjust the pulse generator output to obtain full-scale deflection and minimize the meter reading by adjusting R235.



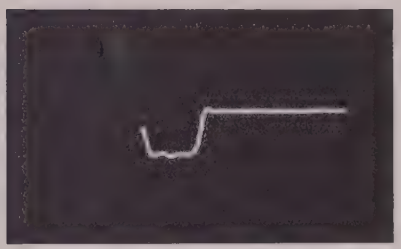
V402 PIN 3
0.5 USEC/CM;
175 VOLTS



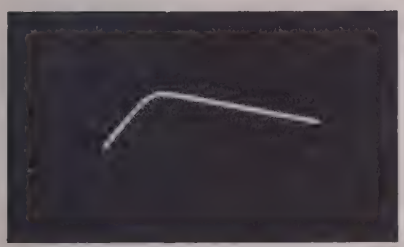
V302 PIN 8
0.5 USEC/CM; 0.4 VOLTS
300 MW RANGE



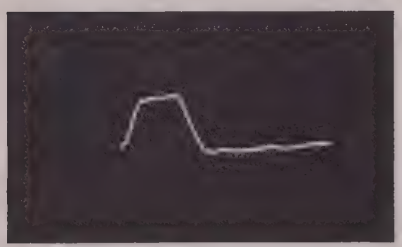
V402 PIN 1
0.5 USEC/CM;
30 VOLTS



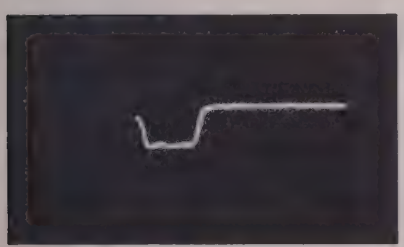
V303 PIN 8
0.5 USEC/CM; 0.4 VOLT
300 MW RANGE



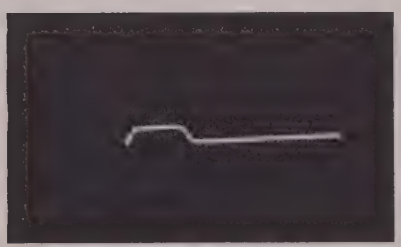
V301 PIN 2
0.5 USEC/CM;
50 MV 300 MW RANGE



V205 PIN 1
0.5 USEC/CM; 10 VOLTS
300 MW RANGE



V301 PIN 8
0.5 USEC/CM;
30 MV 300 MW RANGE



J502 PULSE OUT
0.5 USEC/CM; 0.25 VOLT
300 MW RANGE

Figure 5. Typical Waveforms

17. VOLTAGE CHART

The measurements given in table 4 are from the indicated tube pins to ground. The conditions of measurement are as follows:

a. All measurements taken with a 20,000-ohms/volt meter for dc, 1000-ohms/volt for ac.

b. Ten minutes warmup allowed for voltage readings.

c. After zeroing meter, LEVEL control set for full-scale reading with SELECTOR switch on CAL.

d. BARRETTER switch on 823 and RANGE switch on 300.

e. All voltage readings dc unless otherwise indicated.

TABLE 4

VOLTAGE CHART

Tube	Type	1	2	3	4	5	6	7	8	9
V101	5V4G	-	450	-	375AC	-	375AC	-	450	-
V102	6X4	-385	-	375AC	375AC	-	-385	375AC	-	-
V103	0A2	0	-146	-	-146	0	-	-146	-	-
V104	6BL7GT	260	430	260	255	430	260	260	260	-
V105	6AU6	-2.5	0	3.0AC	3.0AC	260	75	0	-	-
V106	12AX7	260	0	0.95	3.0AC	3.0AC	260	-0.35	0.95	3.0AC
V201	12AX7	260	-23.5	11.5	1.65AC	3.0AC	260	0.5	13.0	3.0AC
V202	12AT7	260	115	120	3.0AC	3.0AC	50	-0.40	0	3.0AC
V203	6AG5	0	2.0	3.0AC	3.0AC	115	92	2.0	-	-
V204	12AX7	0	0	11.5	1.60AC	3.0AC	260	0.70	2.8	3.0AC
V205	6AW8	145	144	260	60	60	0	-0.45	118	145
V301	6U8	260	-0.55	130	60	60	165	0	166	164
V302	12AT7	150	0	1.0	60	60	260	150	150	60
V303	12AT7	155	0	0.95	60	60	260	155	155	60
V401	6AB4	260	0	60	60	-	0.35	22	-	-
V402	6BJ8	0	30	0	3.0AC	3.0AC	0	257	-43	0

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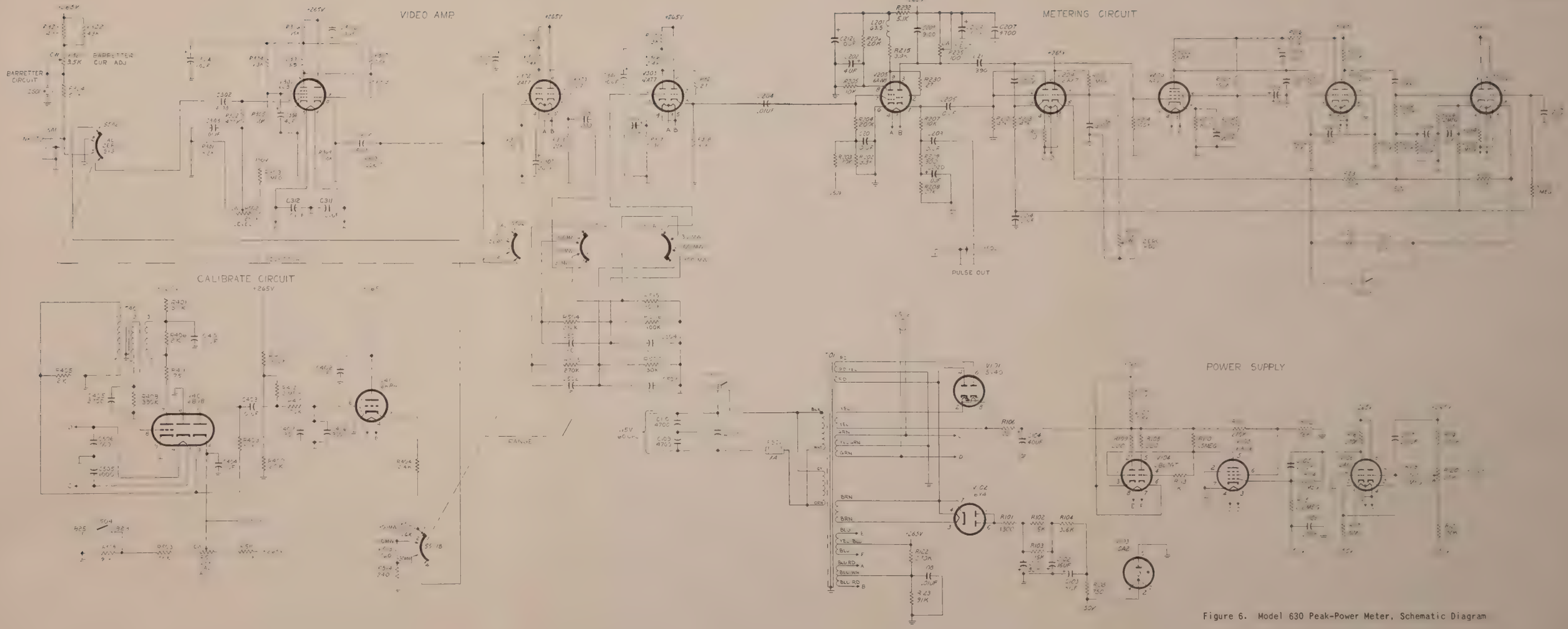

Figure 6. Model 630 Peak-Power Meter, Schematic Diagram

REF. DESIG.	PART NO. (FOR REF.)	NAME	VALUE	TOL.	RATING
C101	746339-06	CAPACITOR	.01UF	+100%	500V, DC
C102	746339-01		10UF		
C103	746339-06		.01UF		
C104	145667		400UF	+10% -20%	
C105	0521-09		.01UF	+100% -20%	
C106					
C107					
C108					
C109	0527-08		4700		
C110					
C111					
R101	0524-82	RESISTOR	1300	±5%	2W
R102	-77		15K		
R103	-77		1.5K		
R104	-64		3.6K		1W
R105	0525-46		750		
R106	0524-65		100		5W
R107	0127-89		2.5K		15W
R108	0525-33		820		1W
R109	0525-33		820		1W
R110	0524-125		1.5MEG		½W
R111	-107		470K		
R112	-91		36K		
R113	-69		1K		
R114	-108		2MEG		
R115	-108		2MEG		
R116	-107		470K		
R117	-93		82K		
R118	-108		2MEG		
R119	0525-107		470K	±10%	1W
R120	7M4018-73	VAR.	25K	±20%	½W
R121	0524-101		150K	±5%	½W
R122	0525-107		470K		1W
R123	0524-96		91K		½W
R124	0101-89		2.6K		1/2W
T101	627698	TRANSFORMER			
V101	178939-2	TUBE, ELECTRON	5V4G		
V102	8601302-2		6AL5		
V103	8136355-2		6BL7GT		
V104	7338643		6AU6		
V105	8601317-2		12AX7		
V106	823494-2		12AX7		
C201	0521-09	CAPACITOR	.01UF	+100% -20%	500V
C202	746339-01		10UF	+100% -20%	250V
C203	0521-09		.01UF	+100% -20%	500V
C204					
C205					
C206	746339-11		20UF	+100% -10%	50V
C207	0521-08		4700	+100% -20%	500V
C208	0521-08		4700	+100% -20%	500V
C209	747272-312		9120	+100% -10%	500V
C210	0521-09		.01UF	+100% -20%	500V
C211	745961-391		330	+100% -10%	450VDC
C212A			10UF	+100% -10%	
C212B	746148-02				
C212C					
C212D					
C213	746339-01		4UF	+100% -10%	250V
C214	624380-104		.1UF	+100% -10%	600V
C215	624580-106		100	+100% -10%	6000V
C216	0521-04		1000	+100% -20%	500V
C217	0521-04		1000	+100% -20%	500V
C218	721883		5UF	+100% -10%	200V
C219	1257-09		.01UF	+100% -20%	500V
C220	610793-06		20	+50% -10%	300V
L201	884449	COIL	63.5		
R201	0524-97	RESISTOR	100K	±5%	½W
R202	-61		5.1K		
R203	-105		220K		
R204	-104		200K		
R205	-98		110K		
R206	-80		30K		
R207	-73		10K		1W
R208	0525-93		27K		1W
R209	0524-36		300		½W
R210	-89		47K		
R211	-1		10		
R212	-101		1MEG		
R213	-80		47K		
R214	-97		100K		
R215	0525-69		3.9K		1W
R216	0525-66		3.3K		1W
R217	0524-47		820		½W

REF. DESIG.	PART NO. (FOR REF.)	NAME	VALUE	TOL.	RATING
R218	0524-104	RESISTOR	200K	±5%	½W
R219	-71		27		
R220	-121		1MEG		
R221	-121		1MEG		
R222	0525-93		68K		1W
R223	0524-101		150K		½W
R224	-90		51K		1W
R225	0525-97		100K		1W
R226	0524-109		2.4MEG		½W
R227	-111		910K		
R228	-103		330K		
R229	-97		100K		
R230	0524-11		47		
R231	0524-97		100K		
R232	0526-66		5.1K		2W
R233	0524-97		100K		½W
R234	-1		10		½W
R235	0524-204	VAR.	100	±20%	2W
V201	823494-2	TUBE, ELECTRON	12AX7		
V202	8178370-2		12AT7		
V203	8039358-2		6AQ5		
V204	823494-2		12AX7		
V205	734688		6AW8		
C301A		CAPACITOR	10	+100% -10%	450VDC
C301B	746148-02		10		
C301C			10		
C301D			10		
C302	0521-08		4700	+100% -20%	500VDC
C303	1257-09		.01UF	+100% -20%	500VDC
C304	746339-01		4UF	+100% -10%	250VDC
C305	015-5		1500	±5%	300VDC
C307	746339-11	CAPACITOR	20UF	+100% -10%	50VDC
C308	0521-04	CAPACITOR	1000	+100% -20%	500VDC
C310	746339-11	CAPACITOR	20UF	+100% -10%	50VDC
C311	0521-09		.01UF	+100% -20%	500VDC
C312	0521-09		.01UF	+100% -20%	500VDC
L301	883377	COIL	3H		
R301	0524-71	RESISTOR	82K	±5%	½W
R302	-113		470K		
R303	-132		3MEG		
R304	-76		13K		
R305	-98		110K		
R306	0526-77		13K		2W
R307	0524-70		75K		½W
R308	0526-80		20K		2W
R309	0524-97		100K		1/2W
R310	0526-76		11K		2W
R311	0525-58		2.4K		1W
R312	0524-28		750		½W
R313	0526-80		20K		2W
R315	0526-76	RESISTOR	13K	±5%	2W
R316	0525-58		2.4K		1W
R317	0524-88		750		½W
R318	0526-84		50K		2W
R319	0524-11		27		½W
R320					
R321			43K		2W
R322	0526-88		45K		2W
R323	0526-98		51K		1W
R324	0525-66		5.1K		1W
R325	0322-184	VAR.	35K	±10%	2W
V301	TE1001	TUBE, ELECTRON-	6AU8		
V302	8178370-2		12AT7		
V303	8178370-2		12AT7		
C401	747581-26	CAPACITOR	.1UF	6MV	500V
C402	747581-26		.1UF		
C403	0527-09		.01UF	+100% -20%	
C404	624280-104		.1UF	+80% -20%	200V
C405	745961-271		2700	±5%	500V
C406	745961-301		3000	±5%	
C407	746103-191		130	±5%	

REF. DESIG.	PART NO. (FOR REF.)	NAME	VALUE	TOL.	RATING
R401	0524-66	RESISTOR	5.1K	±5%	½W
R403	0524-66	RESISTOR	5.1K	±5%	½W
R404	-58		2.4K		
R405	-56		22		
R406	-56		68		
R407	-108		500K		
R408	-111		910K		
R409	-80		20K		
R410	723155-074		100K	±1%	
R411	0524-28		10	±5%	
R412	0524-118		2MEG	±5%	
T401	746262	TRANSFORMER			
V402	7497286	TUBE, ELECTRON	6AB4		
V401	749327	TUBE, ELECTRON	6BJ6		
C501	0323-20	CAPACITOR	20	+30% -10%	500VDC
C502	0323-05		5	±10%	
C503	0323-20		20	±5%	
C504	0323-20		20	±5%	
C505	298833		1000	+50% -20%	
C506	298833		1000	+50% -20%	
F501	841-10	FUSE	3A		
I501	857175	LAMP			
I502	0194-13	LAMP			
J501	712402	CONNECTOR-BNC			
J502	724102	CONNECTOR-BNC			
J503	2552721-01	PIN JACK			
M501	746130	METER			
R501	0322-068	RESISTOR VAR	15K	±10%	2W
R502	0322-075	VAR	250K	±10%	2W
R503	0524-90		51K	±5%	1W
R504	649190-619		2321	±1%	½W
R505	723155-086		9261		
R506	-074		100K		
R507	-041		30K		
R508	0328-36		91K	±5%	
R509	0524-96		36K	±5%	
R510	0322-189	VAR	25K	±10%	2W
R511	0524-110		150K	±5%	½W
R512	723155-051		1.6K	±1%	
R513	-050		560		
R514	-011		240	±1%	
R515	0524-108		300K	±5%	
S501	624795	3 SWITCH-SECT			
S502	6WI5EC103	-ROTARY			
S503	5933-4	-TOGGLE			
S504	0232-1	-TOGGLE			

NOTES:
1. ALL VALUES ARE EXPRESSED IN OHMS, MICROMICROFARADS OR MICROFARADS, UNLESS OTHERWISE INDICATED.
K DENOTES 1,000 OHMS; MEG DENOTES 1,000,000 OHMS.
2. ALL RELAYS AND SWITCHES ARE SHOWN IN THE UNENERGIZED OR OFF POSITION UNLESS OTHERWISE INDICATED.

Figure 7. Electrical Parts List